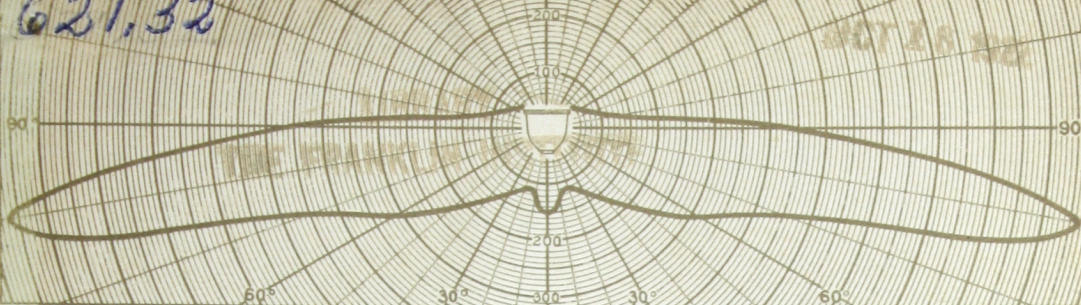
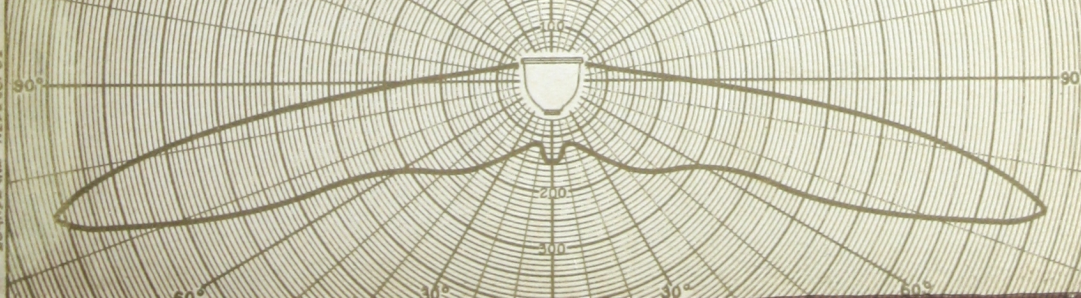
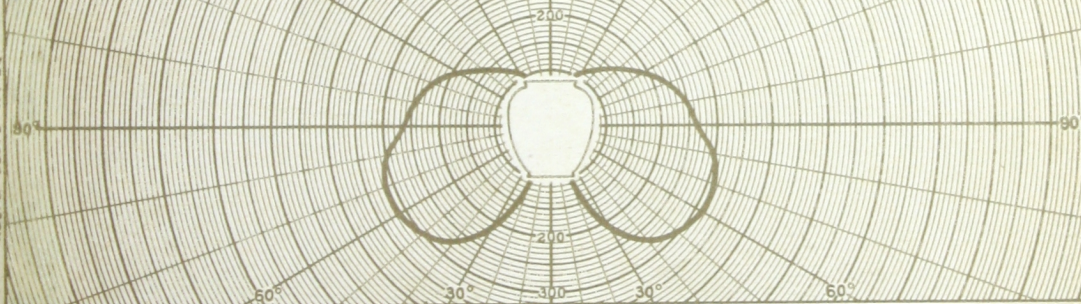
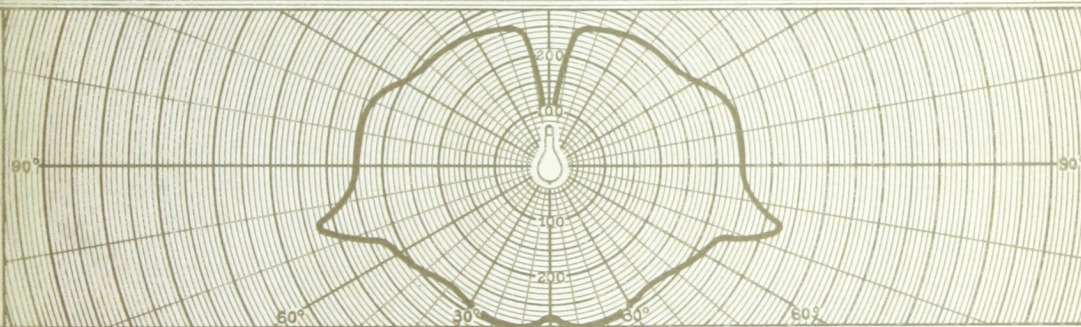


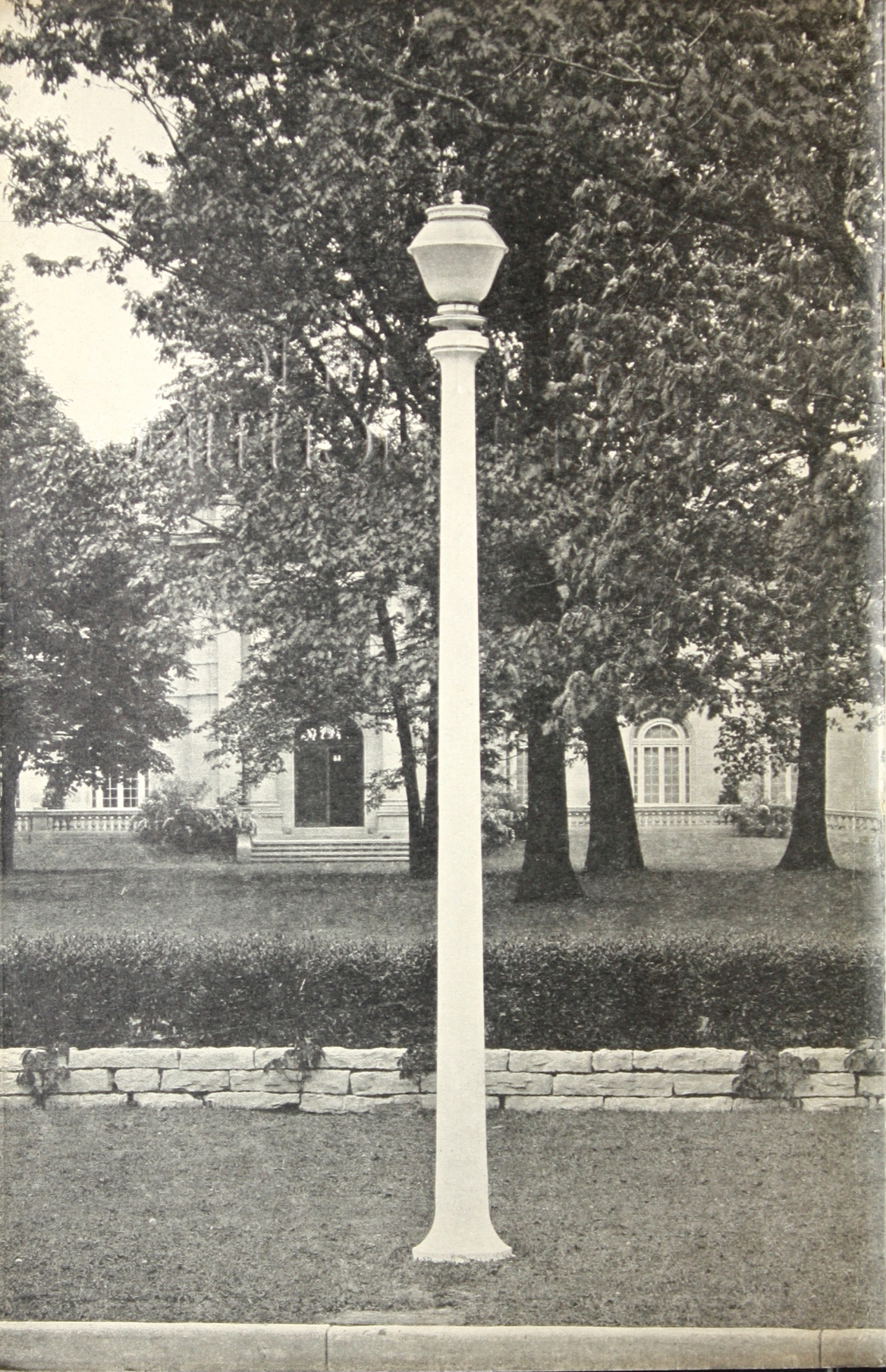
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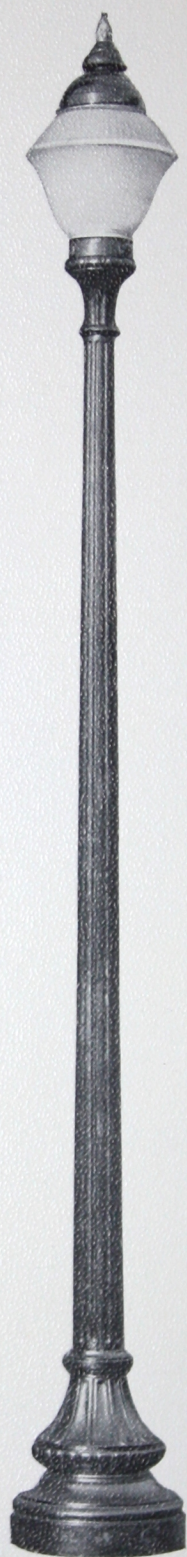
SCIENTIFIC STREET LIGHTING

A GUIDE TO GOOD PRACTICE





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SCIENTIFIC STREET LIGHTING

A GUIDE TO GOOD PRACTICE

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HOLOPHANE GLASS COMPANY, Inc.
342 MADISON AVENUE
NEW YORK

WORKS: NEWARK, OHIO

streets by night are as convenient and as safe as by day. Nor does this involve vast increases over present street lighting expenditures. With the best available equipment installed according to the best practice, such a standard of service can today be attained at a cost approximately twice that of the average present expenditure.

It should be the part of the electrical industry to furnish intelligent and aggressive leadership in this movement toward better street lighting. Every opportunity should be improved to impress the above facts upon public officials and upon the public in general. To date, the better street lighting movement has been largely a blind groping toward meeting a need which has been experienced rather than carefully analyzed and fully understood. As the movement becomes more self-conscious, as the American public more clearly recognizes that, impelled by changed social conditions, it is in process of adopting radically higher standards of street lighting service, the movement will be greatly quickened to the advantage alike of the public and of the electrical industry.

The foregoing paragraphs present the social and the commercial aspects of the trend of street lighting practice. On its engineering aspect, the trend of practice is toward (a) the extension of ornamental lighting, (b) closer spacing in non-ornamental lighting, (c) greater mounting heights, and (d) higher intensity values.

Extension of Ornamental Lighting:— It is a common mistake to regard as permanent the present typical condition under which ornamental lighting is employed on important business streets and, possibly, on the wealthier residence streets, while non-ornamental lighting is employed for the rest of the service. Rather, the ornamental lighting movement is to be interpreted as a blind groping of the public toward the ideal that the street lighting installation should add to rather than detract from the attractiveness of the street. Ultimately, all the built-up sections of our cities will be served by an ornamental system in the sense that the circuits will be underground and the light units and their supports of an ornamental character. Washington, D. C. and Milwaukee, Wis., together with several smaller cities, have already, with varying success, attempted the realization of this ideal. In most of our cities, the influence of the same ideal is shown in a quite general tendency to extend the area of ornamental lighting. The present or future extension of ornamental lighting to serve the complete city, or at least an ever-increasing portion of the city, is a consideration which should be carefully weighed in the design of all new street lighting systems.

Closer Spacings in Non-ornamental Lighting:— A decade or more ago, the ideal in non-ornamental lighting was to provide a street light at each street intersection; and this ideal was attained to only by the more progressive municipalities. Today

a street light at each intersection is the rule rather than the exception, while the more progressive municipalities are beginning to install intermediate lights in the longer blocks. Among street lighting engineers there is a growing realization that only the exceptionally short block can be adequately lighted by lamps at the intersections only. Indeed, if the ideal set forth above as the ultimate ideal is to be attained, if our streets are to be made as convenient and as safe by night as by day, the lamps must be installed on a spacing of approximately 8 times the mounting height. With the suspension mounting, which is generally employed in non-ornamental practice, this will mean a spacing of approximately 200 ft. While no cities are as yet educated to the point of providing the ultimate standard represented by an 8-times-the-mounting-height spacing, the more progressive cities are installing an intermediate unit between street intersection units when the length of the block exceeds 20 times the mounting height.

Greater Mounting Heights:— There is a very gradual but nevertheless positive tendency toward greater mounting heights, both in ornamental and non-ornamental lighting. In the ornamental field, 15 ft. is to be regarded as the minimum mounting height* permissible under first-class practice. Indeed, in business district ornamental lighting, a height of 25 ft., or even greater is generally preferable to any lesser

*Mounting height is always taken as the height of the light center above the street surface.

height. In the non-ornamental field, a height of 25 ft. for suspension units is generally the most satisfactory height, since, at greater heights, there is apt to be interference from the over-hanging boughs of trees and, at lesser heights, the effective illumination extends over a correspondingly lesser area of street.

There is abundant reason to believe that the municipality which employs a lower mounting height than 15 ft. will, by the end of a decade, be as much out of date as is now the municipality which has an installation of cluster lighting.

Higher Intensity Values:— With respect to intensity of illumination, present ornamental lighting practice frequently attains to the ultimate standards set forth herein. While intensity of illumination varies enormously as between different installations of ornamental lighting, the great majority of existing installations will come within the limits of .10 f.c. and .80 f.c., measured in terms of average horizontal illumination on the street surface. To meet the ultimate standards set forth herein, that the street by night shall be essentially as convenient and as safe as by day, the following average intensities of illumination must approximately be provided; in addition to which, as has already been pointed out, the spacing must be sufficiently close to provide a reasonable uniformity of illumination, say not poorer than 4 to 1. The following figures are based on the assumption that the installation is not characterized by excessive glare.

**Lighting Intensities Required to make Streets
by Night Essentially as Safe and
Convenient as by Day**

Classification of Street	Intensity of Illumination (foot-candles)	Approximately equivalent to
Non-traffic streets,	.04 — .05*	1½ times full moonlight
Arterial streets outside of retail business districts, carrying con- siderable automotive traffic and little pedestrian traffic,	.12 — .15	4 times full moonlight
Arterial streets outside of retail business districts, carrying very great automotive traffic and little pedestrian traffic,	.20 — .25	7 times full moonlight
Promenade streets,	.50 — .60**	16 times full moonlight

It should be remembered that, for promenade streets, higher intensities than those above given may be desirable for advertising value. The intensities above given represent only the values required to make the street as convenient and as safe for use by night as by day.

* This represents approximately the service given by a 2500 lumen street series lamp equipped with Holophane bowl refractor and installed on 200 ft. spacings at 25 ft. mounting height, suspension mounting.

** This represents approximately the service given by a 15,000 lumen street series lamp equipped with Holophane refractor and installed, in pairs opposite each other, on each side of the street on 200 ft. spacings at 25 ft. mounting height, ornamental post mounting.

**Light Distribution
Considerations**

About 50% of the light of the Mazda lamp, in types applicable to street lighting service, is emitted above the horizontal; and hence, if the lamp be used without reflecting or refracting equipment, this upward-emitted light never reaches the street. The downward-emitted light is distributed in such a way as to produce a relatively bright illumination directly under the lamp, and for a distance therefrom approximately equal to twice the mounting height of the lamp above the street; beyond which point the illumination rapidly drops away to very low values.

When, as is sometimes done in ornamental lighting, the bare lamp is equipped with white glass globe, the intense brilliancy of the unshielded light source is greatly reduced and a much more pleasing appearance obtained. Whatever the quality of the white glass or the shape of the globe, however, the distribution remains substantially the same as that of the bare lamp, approximately half of the light being emitted above the horizontal and the downward-emitted light being so distributed as to give effective illumination only to a distance of from 2 to $2\frac{1}{2}$ times the mounting height of the lamp.

When, as is sometimes done in non-ornamental lighting, a flat corrugated or a shallow bowl reflector of porcelain-enameled metal is used, a considerable part of the upward-emitted light is intercepted and directed

downward. The downward distribution, however, remains substantially the same as in the case of the bare lamp, the radius of effective illumination being 2 to $2\frac{1}{2}$ times the mounting height.

The Holophane refractor is designed (1) to intercept the upward-emitted light of the lamp and redirect same downwards, so that it shall usefully serve for lighting the street; (2) so to distribute the downward-emitted light as to produce approximately uniform illumination over a much larger area than is the case when the bare lamp is used alone or, indeed, with any other equipment; and (3) so to diffuse the light as to reduce the intense brilliancy of the bare lamp and produce a pleasing appearance.

The Holophane refractor, therefore, will deliver upon the street surface a larger percentage of the generated light than is obtainable from the bare lamp or from any other type of equipment save only open-mouth reflectors. At the same time, the Holophane refractor so distributes the light that the radius of effective illumination is 4 times the mounting height, instead of $2\frac{1}{2}$ times the mounting height as is the case with the best types of competitive equipment.

As compared with the best quality and shape of white glass globe, the Holophane refractor will deliver at least 35% more light upon the street; and this light is far better distributed.

Construction of Holophane Refractor

The Holophane refractor consists of two* pieces of pressed crystal glass nested one within the other and clamped together so as to form a single unit (see Fig. 1). The inside surface of the inner piece and the outside surface of the outer piece are smooth; so that, in the assembled unit, both inside and outside surfaces are smooth, making cleaning easy. The outside surface of the inner piece has horizontal prisms so designed as to bend downward the upward-emitted light and to bend upward the excess in light emitted downward near the vertical (see Fig. 1), thus greatly increasing the light emitted at angles from 60° to 85° with the vertical and hence greatly extending the radius of effective illumination. The inside surface of the outside piece has vertical flutes which, while not materially altering the distribution produced by the inside piece, diffuse the light and greatly reduce the brilliancy from that of the unshielded filament.

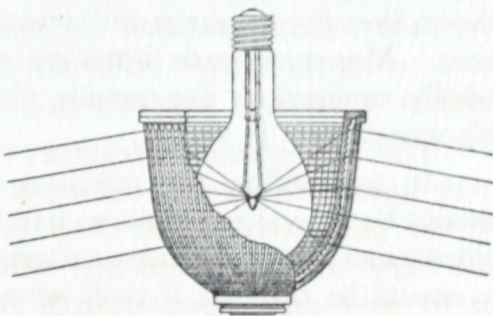


Fig. 1

* In the case of the Holophane No. 4936 refractor there are three pieces, the outside element being composed of two separate pieces.

In short, it is the function of the inside piece to *conserve the upward-emitted light* and to *produce the desired light distribution* while it is the function of the outside piece to *diffuse the light* and *produce an attractive appearance* in the unit as a whole.

The two pieces are so fitted and clamped together that it is impossible for dirt, even in the most finely divided form, to get between them.

The refractor is very rugged in construction and is far less subject to breakage than most other types of street lighting glassware. Extended experience has shown that the breakage will average less than 5% per year. Moreover, such breakage as occurs is almost wholly confined to the outside piece, so that the replacement cost is small.

In assembling the refractor, the clamping nut should be screwed as tight as can be done by the unaided hand without extreme effort, but not as tight as would be the case if tools were used.

Spacing of Light Units Ornamental Lighting:— Where white glass globes are used, the attainment of fully satisfactory uniformity* will require a spacing not exceeding 5 times the mounting

* Uniformity of illumination is customarily expressed by the ratio of maximum intensity of illumination to minimum intensity of illumination. Thus, a uniformity of 4 to 1 means that the most brightly lighted spot on the street is 4 times as bright as the darkest spot, excluding in this comparison all lights other than street lights and all shadows of trees and other objects.

The term "fully satisfactory uniformity", as used herein, represents a uniformity of 4 to 1 or better. The term "fairly satisfactory uniformity" represents a uniformity poorer than 4 to 1 and better than 12 to 1.

height. The limit of what may be called fairly satisfactory practice, as distinguished from fully satisfactory practice on the one hand and from poor practice on the other, is reached at spacings of from 7 to 8 times the mounting height. Where Holophane refractors are used, fully satisfactory uniformity can be attained at spacings not exceeding 8 times the mounting height; while fairly satisfactory uniformity is attained at greater spacings not exceeding 12 times the mounting height.

The much wider spacing with equally good lighting service made possible by the Holophane refractor improves the ornamental effect and materially decreases both the installation and operation costs. While the purchase price of the Holophane refractor is higher than that of any white glass globe, its greater efficiency and the wider spacing made possible by its use make it incomparably the more economical globe to employ.

Non-ornamental Lighting:— As has already been pointed out, if the ultimate ideal is to be achieved, if the street is to be lighted so as to be as convenient and as safe of use as by day, a spacing approximately 8 times the mounting height must be employed. But while this spacing should be well advertised as the ultimate point toward which practice is tending, present standards of service fall so far short of the ultimate that the latter becomes only an indirect factor in

determining present practice. In planning an installation, therefore, the engineer will first of all be guided by the fact that a light unit should be placed at each street intersection, since at this location the unit is effective in lighting both streets. If the block, measured from center line to center line of intersecting streets, exceeds 20 times the mounting height, one intermediate unit should be provided at the mid-way point. If the block exceeds 32 times the mounting height, two intermediate units should be provided at the one-third and two-thirds points respectively.

Glare The term "glare" is loosely used to designate two entirely distinct and independent phenomena, — (1) the *immediate ocular discomfort* which one experiences in looking at an intensely bright light and (2) the *blinding effect* of the lamp.

If a white glass globe or a Holophane refractor be employed, the ocular discomfort, as compared with that produced by the bare, unshielded lamp, is greatly decreased. The blinding effect, however, is not reduced by the use of either white glass globe or Holophane refractor.

So serious is this blinding effect that, at a mounting height of $13\frac{1}{2}$ ft., a 4000 lumen lamp in white glass globe produces a blinding effect equal to a waste

of half the light: that is to say, if this blinding effect could be eliminated, a 2000 lumen lamp would light the streets so that objects could be seen just as clearly as with a 4000 lumen lamp under the conditions first stated.

The one practical way to avoid the serious wastes due to blinding effect (or, as it is customarily called, glare) is to employ higher mounting heights. As compared with a mounting height of $13\frac{1}{2}$ ft., the glare is only one-half as bad at $18\frac{1}{2}$ ft. and only one-quarter as bad at 27 ft.

As has already been stated, 15 ft. is to be regarded as the minimum mounting height permissible under first-class practice.

A high mounting, made desirable by considerations of glare, is also desirable in that it permits of a wider spacing of light units with equally good lighting results and with consequent economy in installation cost.

Actual experience has shown that the average citizen, when he has seen with his own eyes the quality of lighting, relatively glareless, made possible by mounting heights of 25 ft. to 35 ft., greatly prefers such lighting to that characteristic of lower mounting heights.

Non-ornamental Lighting:— The following rules will determine the size of lamp best to be employed, under existing expenditure limitations, in non-ornamental lighting. In this connection, it must be realized that fully satisfactory standards of practice are almost never attainable under the expenditure limitations set by municipal officials as the maximum permissible, and that the problem is so to expend the appropriation for street lighting service as to produce the best results attainable thereunder.

1. Never employ a smaller size of lamp than 1000 lumens (100 c. p.).
2. Do not use any larger size of lamp than 1000 lumens until a light unit of this size has been provided for each street intersection in the built-up district, for each point where a street crosses a steam railway at grade, and, on approximately a 16-times-the-mounting-height spacing, along each important traffic street outside the built-up district.
3. If the street lighting appropriation is more than sufficient to meet the conditions of 2, increase the size of light unit on important traffic streets of the built-up district to 2500 lumens.
4. If the street lighting appropriation is more than sufficient to meet the conditions of 3, increase the size of all units to 2500 lumens.
5. If the street lighting appropriation is more than sufficient to meet the conditions of 4, install intermediate 1000 lumen units on all blocks of the built-up

district in length exceeding 20 times the mounting height (2 intermediate units if length exceeds 32 times the mounting height.)

6. If the street lighting appropriation is more than sufficient to meet the conditions of 5, increase the size of intermediate units to 2500 lumens.

7. If the street lighting appropriation is more than sufficient to meet the conditions of 6, increase the size of all intersection units to 4000 lumens.

8. If the street lighting appropriation is more than sufficient to meet the conditions of 7, provide a spacing of 8 times the mounting height on all important traffic streets within and without the built-up district, using thereon 4000 lumen intersection lamps and 2500 lumen intermediate lamps within the built-up district and 2500 lumen lamps throughout outside the built-up district.

9. If the street lighting appropriation is more than sufficient to meet the conditions of 8, provide a spacing of 8 times the mounting height throughout the built-up district. Use 6000 lumen lamps for intersection units, and 2500 lumen lamps for intermediate units.

10. If the street lighting appropriation is more than sufficient to meet the conditions of 9, employ 6000 lumen intersection units and 4000 lumen intermediate units on all main traffic streets of the built-up district.

The conditions set forth by rule 2 represent an absolute minimum below which the street lighting service can only be characterized as utterly inadequate,

utterly unworthy the standards of American civic practice. The conditions set forth by rule 7 represent what may, comparatively speaking, be called first-class present-day practice.

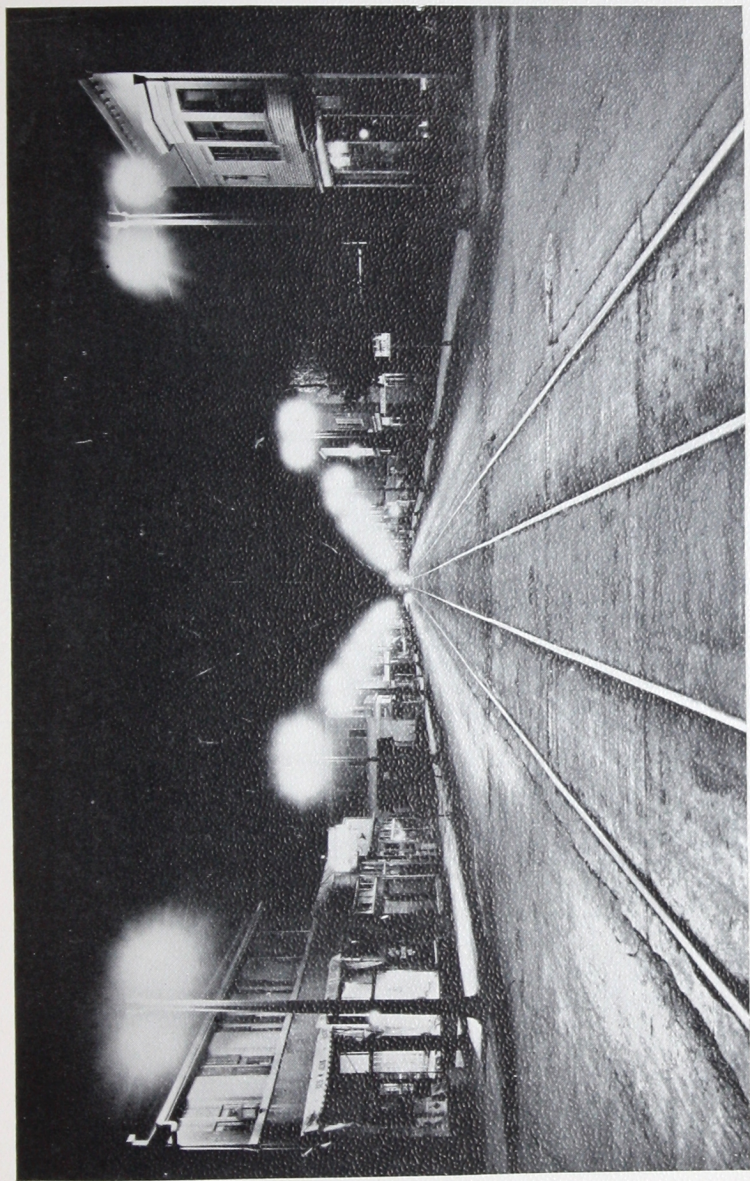
**Service: A Personal Message
to the Reader**

The name Holophane stands not for a product alone, but for a *service made possible through a product*. The Holophane Glass Company, Inc., is keenly interested in all that pertains to lighting practice, is keenly interested in *your* problem in its every aspect. If you desire any help not sufficiently afforded by the foregoing data, a statement of your problem addressed to

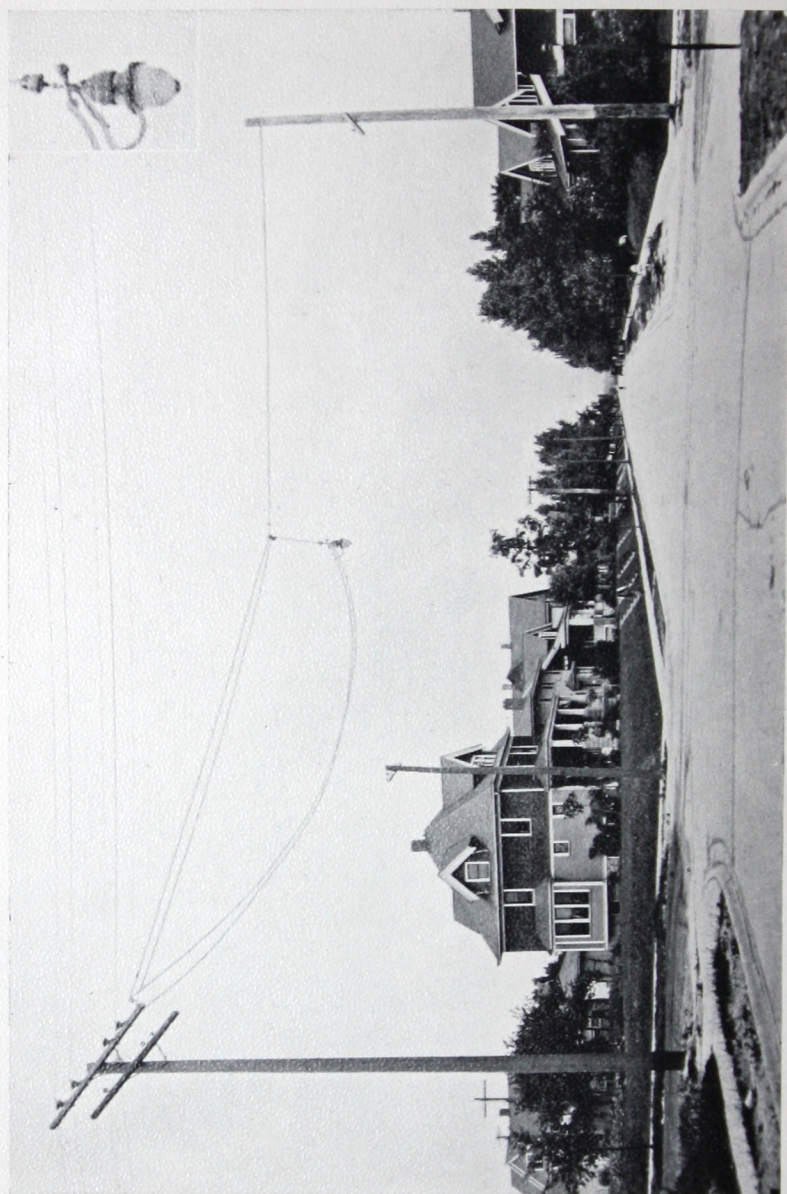
Holophane Glass Co., Inc.,
342 Madison Avenue,
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will bring a prompt reply by competent engineers. This service is freely yours without any obligation whatever to purchase Holophane. It is gladly given in full faith in and unalloyed devotion to the philosophy,

He Profits Most Who Serves Best



Actual night view of street lighting service afforded by installation shown on second page here following. Note how clearly street can be seen to the very end of the ornamental installation, 1400 feet away.



An example of good practice where cost considerations necessitate non-ornamental lighting



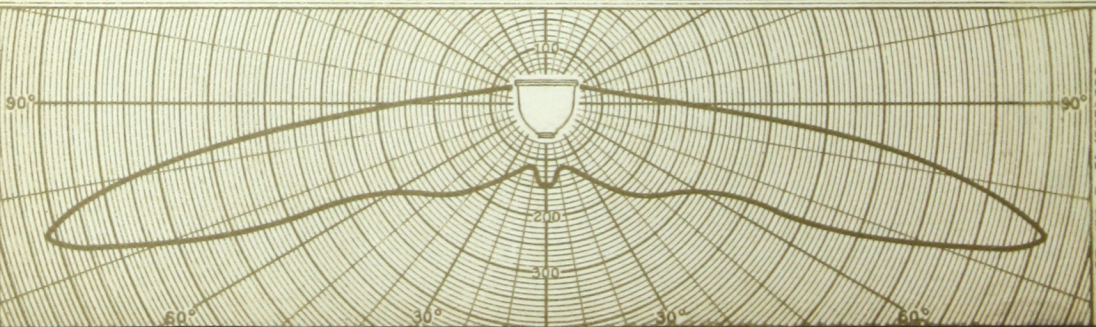
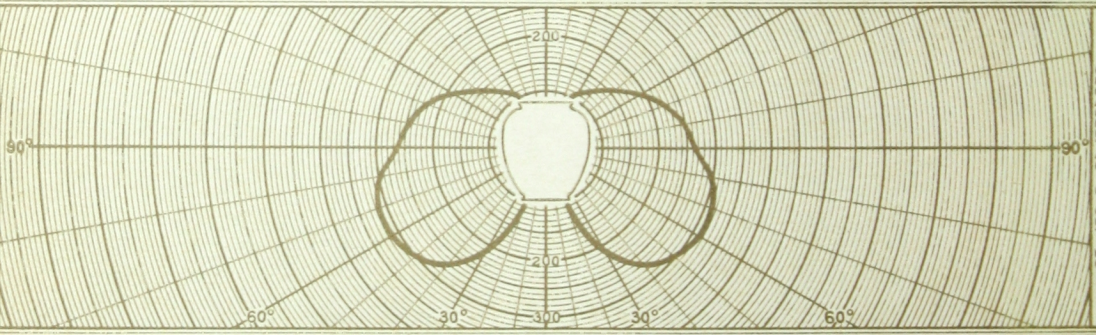
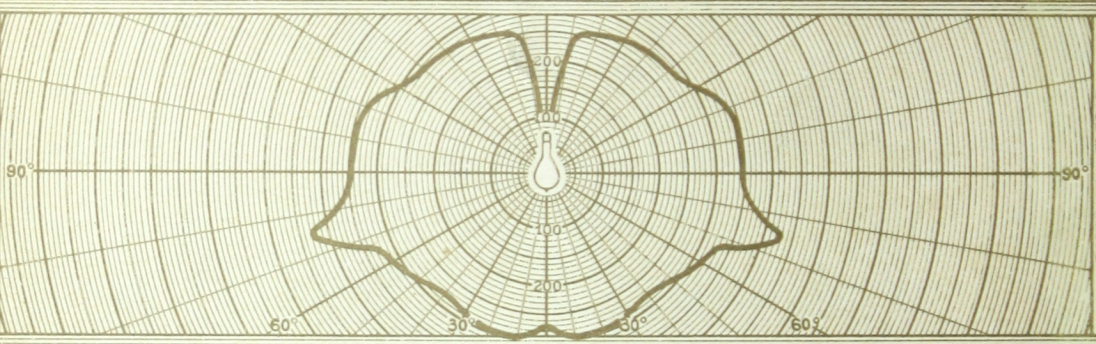
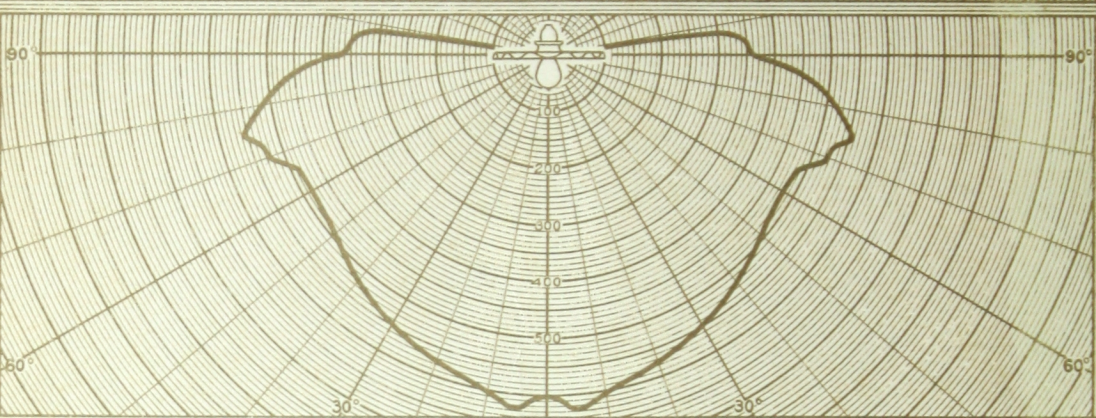
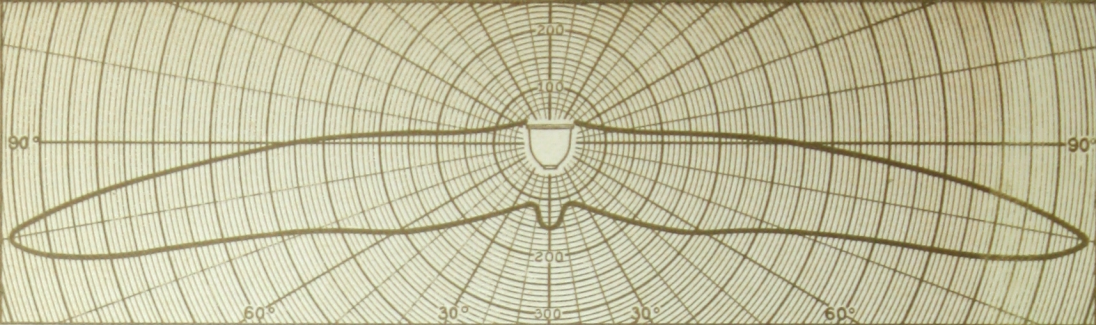
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